R E F E R E N C E G U I D E

Babbitt Bearing Alloys

I S 0 9 0 0 2   Q S 9 0 0 0   F o r d Q - 1

Contents

(Photo of Fry Technology's Babbitt Casting Department. Fry Technology is the world's largest tin/lead fabricator under one roof!)

Considerations in Selecting a Bearing Alloy

Properties of the Alloys: Tin-base babbitts commonly contain copper and antimony following the pattern, though not necessarily the proportions, of Isaac Babbitt's original alloy. They have hardness up to 32BHN which gives them excellent load-carrying characteristics. They show low friction resistance, low wear, good run-in properties and good emergency behavior in the absence of adequate lubrication. They "wet" easily and maintain an oil film, resist corrosion, are easily cast and bonded and retain good mechanical properties at elevated temperatures. Conventional lead-base babbitts contain antimony and tin, which greatly increase the strength and hardness of lead. Properties of the lead-base alloys improve with the addition of antimony up to a maximum of 18%, above which the alloy becomes excessively brittle. The addition of tin to the lead and antimony improves mechanical and casting properties. At 10% tin, room-temperature strength and hardness reach a maximum. The lead-antimony-tin alloys are not the equal of tin-base alloys but are fully adequate for lower loads and moderate temperatures. Though alloys with lower tin content are easier to handle in the kettle, they are more difficult to bond. The very good frictional properties, reasonably good corrosion resistance and low cost of the lead-antimony-tin alloys makes them ideal for a wide range of applications.

The lead-antimony-arsenic alloys are the equal of tin-base alloys in their ability to retain hardness and strength at elevated temperatures. In this respect they are superior to conventional lead-base alloys.

Bearing Operating Conditions: The method or efficiency of lubrication is one of the factors affecting the choice of an alloy. Under poor lubricating conditions, an alloy of good conformity and run-in behavior is required.

Temperature, rotating speed, pressure per unit area and even the procedure for fabricating the bearing have an influence on alloy selection; the design of the bearing and its bonding are also significant. For example, a thick lining, mechanically anchored, requires a babbitt of good ductility at room temperature that will seat itself in the anchors under load. The tin-base alloys, which have good plasticity at room temperature, adjust well to these conditions under moderate to severe loads.

For bearings which are difficult to seal and align, and where line contact occurs in the early moments of operation before full lubrication is established, the conventional lead-base alloys have the required ductility and conformability. Their use is limited, however, to moderate speeds and loads.

Where thin linings and precision castings are used, certain lead-base alloys containing only a nominal 1% tin should be considered; in properly designed and properly cast bearings they perform as well as tin-base babbitts and are much less expensive. They have excellent fatigue resistance, which is important to bearings of this type. Naturally, they do not have the ductility of lead-base antimony-tin bearings but this is a minor factor with thin liners.

Most important of all: In selecting a bearing alloy, seek the advice of your Fry Technology representative. Through Fry Technology you can draw on our group's Central Research Department and their many years of experience in the theory and application of bearing alloys.

Melting of Bearing Alloys

Because of the relatively low melting point of bearing metal alloys, it is easy to convert ingots to liquid alloy. To make molten metal suitable for casting, however, requires careful control.

The melting pot can be of any size suitable for the amount of metal needed. Heat-resistant iron containing nickel, chromium or molybdenum is the preferred material for its long service life. Clay graphite crucibles are sometimes used where contamination from iron is a serious problem. ***The melting pot must be clean*****.** After melting, the pot should be scraped to remove accumulations of metal and dross. If not, subsequent casting may show hard spots on the machined surface.

A semi-spherical melting pot with a flange supported by a refractory shell is recommended, and heating should be arranged so that a uniform temperature prevails throughout the melt. Uneven heating may cause segregation or allow partial solidification. Segregation may occur in tin-base alloys of high copper content and may result in a deposit in the kettle after pouring which is much higher in copper than the desired alloy. This obviously deprives the cast metal of some of its specified alloy content of copper.

After complete melting, the metal should be stirred, manually or mechanically, to insure uniformity of the melt but carefully to avoid producing too much dross. Manual stirring is best done with a circular perforated plate on a long-handled steel rod. Stirring is from the bottom upward using a figure “8” motion. After stirring, the metal should remain at rest for a few minutes, then be skimmed. The temperature of the melt should be controlled-or checked-by pyrometer. Constant thermal control is required for efficient and uniform results. High temperatures lead to excessive drossing, which is wasteful. Further, dross may be carried over into the casting and cause failure of the bearing. Also, fuel costs are higher and pot life shortened.

On the other hand, a melt temperature which is too low can cause segregation in the pot as well as premature solidification before bonding on the shell takes place. The most suitable pyrometer is the shielded type which is submerged in the melt and records on a wall-mounted instrument.

No portion of the melt should ever be allowed to remain between the solidus and liquidus temperatures for any length of time. This often happens when the casting set-up is not quite ready or when metal is left overnight for use the next day. Under these circumstances, crystal aggregates are precipitated. The heavier crystals sink, the lighter float. Stirring after reheating does now always dissolve all the crystals and the result may be hard spots in the bearings. Above all, metal should not be allowed to solidify in the melting pot overnight. Unused metal at day's end should be poured into pigs, and the pot thoroughly cleaned before re-use.

Accumulations of dross, sweepings, skimmings and machine-shop borings should be sold to a smelter or collector, not used in the pot. ***Clean borings of known constituents may be used in the melt if magnetically screened to remove ferrous chips and particles.*** This will not remove brass and bronze chips which may also be harmful. Of course, alloys must not be mixed. It cannot be emphasized too strongly that metal waste should be sold rather than re-used. If used, it must be clean and sorted with scrupulous care. Good housekeeping is imperative to the casting of dependable bearings.

Additions to the melt should be made in such a way as to assure rapid coalescence with the bath to prevent oxidation of the metals being added.

Handling Babbitt Bearing Alloys

When melting, pouring, machining or otherwise working with these alloys, care should be taken to comply with health standards promulgated by the Federal Occupational Health and Safety Administration or the state equivalent relating to the concentrations of airborne metal fumes and dust and work practices. Upon request, Fry Technology will supply to customers copies of Material Safety Data Sheets for the major constituents of these alloys. Employees should be fully informed of any hazards that may exist and the necessary steps to be taken to eliminate or minimize them.

Bonding the Bearing

There are two basic methods - chemical *or metallurgical*, and mechanical - by which babbitt metals are bonded to the supporting shell. Chemical bonding is the preferred modern practice and is used almost exclusively. Mechanical bonding is sometimes used for bearings of an inch or more in thickness which are secured to the shell with the help of grooves, dovetails, anchors, undercuts or holes to keep the bearing metal in place.

The metallurgical bond is a thin layer of alloy between the bearing metal and the shell or support; the bond alloys with both, and secures them firmly in relation to one another. The bonding layer, though strong, is brittle and must be as thin as is practicable to minimize stress concentration in the area.

Tin-base bearing alloys are commonly bonded to steel and bronze shells. In the former case, tin-iron compounds are formed at the bond and in the latter, tin-copper. The tin-copper compound is weaker than the tin-iron compound and dictates the preference for steel shells, though bronze shells are serviceable if bonding is properly done.

Lead-base alloys give equally good results with either type of shell. For arsenic-hardened alloys, the steel shell is preferred. Bronze shells invite the possibility of forming a weak and brittle copper-arsenic bonding layer. This can be avoided, however, by careful control of shell and bearing metal temperature and by rapid solidification of the bearing metal into the copper constituent of the bronze.

Cast iron shells require special treatment due to the formation of a graphite layer on the iron during acid cleaning. However, there are processes using molten caustic salts which can be used to prepare the surface for bonding.

Of major importance to successful bearings is ***thorough*** physical and chemical cleaning of the shell before bonding. A clean bond will prolong the life of the bearing and provide for more than normal load.

Chemical Bonding: The primary requirement in bonding is a perfect jointure between shell and bearing metal. Thorough cleaning is imperative. Following is one procedure:

Machine shell to a "phonograph" finish; so-called because it looks like the scoring seen on a phonograph record. Avoid a smooth, over-fine surface.
Avoid sand blasting. Make the last machine cut without using a cutting compound. Do not wipe the machined surface with waste. Avoid unnecessary handling.

Cleaning: Remove all oil or grease, including fingerprints, by the following procedures:

(a) Suspend shell in solution of commercial alkaline cleaner at a temperature near the boiling point.

or Suspend shell in a solution of molten caustic soda. (Time for either of the steps above is usually 5 to 10 minutes depending on results as observed by inspection.)

(b) Rinse in clean water.

(c) Dip shell in a 50% solution of hydrochloric (muriatic) acid and water at 160 to 180°F and etch for 3 to 5 minutes or just long enough so that the etching effect can be seen. (If shell still shows signs of oil or grease, the complete cleaning cycle must be repeated).

Fluxing: Dip shell in flux solution at temperature of 150°F or per manufacturer's instructions. (Babbitting fluxes are available from Fry. Otherwise, a saturated solution of two parts zinc chloride and one part ammonium chloride in water is satisfactory).

Tinning: <u>Method 1:</u> (tin dipping) Apply the tinning alloy by dipping the shell. The alloy may be molten tin, solder of various grades, or tin-lead-antimony alloys. The alloy should be maintained at a temperature about 150°F above the liquidus temperature of the tinning alloy. Keep shell submerged until it has reached the temperature of the metal bath. On removal, the shell should appear clean and silvery.
A yellow tone indicates that the surface is oxidized because the bath temperature is too high. If so, cool metal and re-flux. The shell is now ready for casting and should be held at a temperature which will keep the tinning alloy molten as the bearing alloy is poured on the shell.
<u>Method 2:</u> (tinning paste) Apply a thin coat of Fry's POWERBOND® 4100 Tinning Paste or other commercially available product to the shell lining at room temperature. NOTE: When pouring a tin based babbitt (Grades 1, 2, 3, or 11), use a tinning paste that contains pure tin such as POWERBOND 4100 LF. When pouring a lead based babbitt (Grades 7, 8, 13 or 15), use a tinning paste with 50% tin/50% lead such as POWERBOND® 4100 SP. Heat the shell until the tinning paste melts (600 - 650°F). Wipe the surface with a clean rag followed by a hot water rinse to remove any residual flux.
<u>Method 3:</u> (tinning compound) Preheat bearing shell to approximately 500° - 550°F. Sprinkle Fry's POWERBOND® 4200 Tinning Compound on bearing surface and vigorously wipe with a stainless steel wire brush to yield a smooth, well-tinned surface to which babbitt readily bonds. Flux residues should be removed with hot water immediately after tinning. Tinning compounds are particularly useful on cast iron and other large bearings when tin dipping and other tinning methods are not practical.
When bonding must be done in the field, other procedures must be followed. They will produce satisfactory results if carefully done as follows:

(1) Remove old bearing metal with blow torch. Avoid excessive heat so that the bonding coat will not be oxidized.

(2) When all old metal is removed, apply flux and brush thoroughly. If the surface is now clean, the shell may be set up for casting. If uncoated spots remain, apply a stick of bonding metal to the hot shell. Re-apply flux until surface is seen to be ready for casting.

(3) Again, the shell must be sufficiently hot to keep the tinning alloy molten while pouring the bearing.

Mechanical Bonding: In mechanical bonding, cleanliness is as important as in chemical bonding. Gas-forming dirt will cause bubbles. Temperature control is required to maintain a differential between mandrel and shell which will insure that solidification proceeds from the shell outward to the mandrel and from bottom to top.

The Casting of Bearing Alloys

Static-Cast Bearings: Static or still-cast bearings can be poured either horizontally or vertically. Vertical pouring is preferred since it affords better control of pouring and cooling. Still casting involves the use of a mandrel with the shell. Temperature control of both is important. The shell should be at or above the melting point of the bonding or tinning metal. With pure tin as the bonding agent, shell temperature should be about, but not less than, 450°F. The mandrel should be about 100°F above shell temperature so that solidification will proceed from shell to mandrel. Thus, the hot metal will feed toward the shell in cooling and the area of solidification shrinkage will be machined off in finishing the bearing. This also prevents shrinkage cavities between the lining metal and the shell. In any case, both shell and mandrel must be held at no less than the melting point of the tinning alloy.

The shell can be brought to the proper temperature by submersion in the pot of molten bonding metal. All except the surface to be bonded should be protected with a mixture of whitewash, fireclay or one of the proprietary lacquers made for the purpose. The mandrel is usually heated by an open-flame torch. For each job a temperature limit determined by experiment should be observed. If a contact pyrometer is not available, chemically compounded pencils of definite melting point can be used. Mark the shell and mandrel with a pencil of the desired melting point and remove the heat source the moment the pencil mark begins to melt. Solidification of the metal at the shell can be hastened (and rapid cooling is desirable for fine grain size) by blowing with compressed air or spraying the shell with water. Care should be taken to insure that cooling is uniform. Adherence of metal to the mandrel is prevented by brushing with dry or colloidal graphite or by depositing lampblack from a smoky flame.

The mandrel should be of steel or cast iron, and accurately machined. Jigs will aid in placing shell and mandrel in their proper relative position. Bottom plate and other components should fit accurately to prevent leakage of molten bearing alloy. All accessories should be ready for pouring so that the bearing alloy can be poured in seconds after the shell has been removed from the tinning bath. Pouring may be done directly in the space between mandrel and shell or by suitable gates and runners. In direct pouring, the ladle should be moved around the cavity and the metal poured against the mandrel. Pouring from a single position overheats the shell or mandrel and leads to stresses, tearing or cavities detrimental or ruinous to the bearing. The ladle should be large enough so that one pouring completes the bearing. Multiple pouring for one bearing invites cold shuts and laminations, or folds. With large bearings, provision must be made for shrinkage as the metal cools. For this purpose, risers of 2 to 6 inches in height will serve. It is sometimes advantageous to puddle the alloy after pouring to minimize both porosity and segregation. Use steel rods with an up-down motion immediately after pouring. While stirring, additional alloy can be added to the riser as the level of the metal recedes.

Centrifugally Cast Bearings:

Centrifugal casting of bearings is done by placing the shell, usually a cylinder, in a horizontal holding device supported in a lathe or similar equipment. An accurately machined plate at each end of the bearing maintains its position and prevents the alloy from running out. The molten metal is poured into a funnel feeding into a center-hole in one of the plates.

When the shell is securely clamped, the lathe is turned up to a predetermined speed and a predetermined amount of alloy is poured into the funnel. Immediately after casting, a water or air-water spray is used to cool the shell.
In theory the operation is simple but there are critical factors: preparation of shell, speed of rotation, thickness of lining, pouring temperature and rate of cooling. Centrifugally cast bearings are always chemically bonded. Preparation of the shell includes caustic bath or other cleaning, rinsing, etching, fluxing and tinning as previously described.

During solidification, solid constituents of varying specific gravities freeze out of the molten alloy. Centrifugal force itself causes segregation due to the difference in specific gravity of solid and liquid constituents in the semi-solid state. In tin-base alloys the heavier copper-tin compound tends toward the center. Similarly, a lead-base alloy segregates lead-rich phases toward the periphery and antimony-rich phases toward the center. Since some of the lining will be machined off, it is clear that the finished bearing, if segregation is not controlled, will not be of uniform composition or identical with the molten alloy.
Rate of rotation is an important element of control. It varies from about 60 rpm for very large bearings to about 1500 rpm for small sizes. Bearings of 4 to 20 inches diameter are rotated at 400 to 600 rpm. It is important to determine the optimum speed of rotation for each size of bearing. Speeds too low will fail to produce a good bond; speeds too high cause excessive segregation.
Thickness of the bearing is a factor to be considered, because it is almost impossible to prevent segregation in a really thick lining. Centrifugally cast linings usually do not exceed 0.125 inches in thickness, including allowance for machining.

Pouring temperatures for tin-base alloys usually range from 800 to 900°F; for lead-base alloys from 900 to 1050°F. Temperature should be as low as possible to fill the mold without causing lamination, cold shuts and other faults. Excessively high temperatures cause slow cooling and segregation. Chilling should start immediately after pouring. Lead-base alloys should be quickly chilled using water. An air-water spray is used to cool tin-base alloys since excessively fast chilling can result in a defective bond.

Preparation Methods for Cast Lined Bearings

A major consideration when lining bearing shells, is the need for a strong bond between the babbitt and the backing material. The backing is first tin coated by immersion in molten tin so that when the babbitt is cast on the surface, a good metallurgical bond is obtained. Since the process consists of melting and re-solidification of the alloy, conditions must be carefully controlled so that the optimum structure for bearing performance is obtained in the babbitt and a uniform composition is achieved, i.e. segregation effects are minimized. Bearing shells are commonly made of steel, bronze, gunmetal or cast iron and varying degrees of surface preparation are necessary before tinning.

Steel Shells

These may be prepared by machining, grinding, grit blasting or by acid pickling. When the steel is to be pickled, it is generally necessary to degrease the surface first. For removal of gross amounts of mineral oil and grease, vapor degreasing or combined vapor and solvent degreasing is effective; however, when certain protective greases and machining compounds must be removed, this must be supplemented or replaced by treatment in hot alkaline solutions. For the general run of engineering steels, hydrochloric acid (about 50% v/v) is a satisfactory picking medium and may be used at room temperature. After rinsing in water, it produces a smut-free surface even on higher-carbon steels. Hot sulfuric acid is less frequently used as a pickling medium. In the case of bearing shells made from rolled steel strip, preparation may be complicated by the need to remove refractory surface layers resulting from rolling and annealing operations. Etching in dilute (10%) nitric acid, may be required and normally a light pickling treatment would follow such special surface preparation. Alternatively the mechanical preparation treatments will usually prepare such surfaces.

When grit- or shot-blasting is employed as a pre-treatment, it is essential to control the process so that every part of the surface to be bonded is efficiently treated. This technique is preferred by some operators, since it gives a good level of adhesion and avoids acid-handling problems, but sometimes leaves particles of the blasting medium embedded in the surface.

After surface treatment, the steel shells should be dipped in an aqueous zinc chloride-based flux solution and then immersed slowly in a bath of molten tin maintained at about 570°F. A fused flux cover should be provided on the tin and the bearing shells should be kept immersed for sufficient time to attain the same temperatures as the tin. Preferably the tinned shells should then be transferred to a second flux-free bath at 450°F - 480°F before finally being babbitted. This has the virtue of bringing the shell to the correct temperature for casting and also of washing off any residual flux from the surface.

Bronze Shells

In the case of bronze shells, clean, machined surfaces only require degreasing prior to aqueous fluxing and tinning since copper-base alloys (with the exception of those containing significant, e.g. >1%, amounts of aluminum) are more easily wetted by tin than are ferrous materials. Wetting incurs the formation of a layer of inter-metallic compounds; this is brittle and has little capacity to withstand deformation under stress, so that in the case of copper-base materials on which such an alloy layer forms more quickly than on ferrous alloys, the time and particularly the temperature of tinning should be kept to a minimum to achieve a completely tin-coated surface: for example a few seconds at 480°F for thin-walled bronze bearings. However, some workers have indicated that in the case of gun-metal castings, longer immersion times do not appear to have a deleterious effect.

Cast Iron Shells

The methods commonly used for tinning steel are not satisfactory for cast iron because of the presence of graphite in the structure of the metal. Moreover, iron castings may have a surface skin, high in silica, which must be removed prior to tinning. Pickling would result in a smear of graphite over the surface which would impair complete tinning. Considerable research at the International Tin Institute resulted in the Direct Chloride Process for tinning of cast iron. In this process, the iron is first shot-blasted with BS 410 70 mesh (approx. 200 um aperture) angular chilled iron grit until a matt uniform grey surface is obtained without allowing contamination by grease to occur; the shell is then briefly immersed in an aqueous flux solution (typically 24 kg zinc chloride, 6 kg sodium chloride, 3 kg ammonium chloride, 1 litre HCI, water to make 100 litres). It is then ready for tinning in a bath on which floats an ebullient molten flux mixture. This is composed of 8 parts zinc chloride crystals, 2 parts sodium chloride and one part ammonium chloride which is available from Fry Technology such as Rolsalt 995. A layer about 1 cm thick is spread on the molten tin surface and sprayed with water from a fine rose. The prefluxed cast iron bearing shell is passed through this ebullient flux blanket, which is an essential feature of the Direct Chloride Process, since it provides a final cleaning of the iron as it enters the molten tin.

Cast iron benefits from extended immersion times during tinning (10 - 20 minutes) in order to counteract the porosity of such castings. Ferrous bearing shells (steel or cast iron) may be redipped in a second bath of molten tin, held at a lower temperature (e.g. 250-260°C), a small quantity of tinning oil sometimes being applied to the bath surface. This is particularly useful when tinning heavy shells, since it helps to maintain a rather thicker and more continuous layer of tin on the work and helps to release any flux entrapped in surface pores from the first tinning stage. Also the temperature of the shell is then more suitable for immediate casting of the whitemetal as there is less tendency for the tin coating to develop a yellow film of oxide during the time required to assemble the shell in its jig for casting.

In some plants, the bearings are cooled after the first tinning and the second immersion used to reheat the shells immediately before lining with babbitt.

Exterior surfaces which are not required to be tinned may be protected by applying a magnesium oxide/ sodium silicate mixture or a dispersed graphite coating, but it is often more economical merely to brush and wipe off any tin adhering to these surfaces.

Other preparation processes involve electrolysis in fused salt baths. Extensive safety precautions are necessary when operating these processes.

One of the most widely used is that developed by the Kolene Corporation of Detroit, USA. The cast iron part, located in a suitable cage container, is first preheated to about 750°F and then dipped in a bath of molten sodium hydroxide, with controlled additions of sodium nitrate and sodium chloride, for 10 - 15 minutes at around 900°F. The workpiece and the interior of the tank are connected to a low-voltage DC supply and the polarity of the current can be reversed, so that the cast iron may be treated anodically, cathodically, or by a combination of these. This treatment removes graphite from the surface of the cast iron by oxidation and also eliminates casting skins and surface oxides. This is followed by successive dips in a hot water rinse, a 20% HCl solution for 5 - 10 minutes to deoxidize the surface and to neutralize alkali, and finally a hot water rinse.

Electrolytic treatments in simple fused sodium hydroxide baths are also practiced and the effects are similar. The difficulty of tinning over a graphite contaminated surface can also be overcome by first electroplating the casting with a readily tinnable metal such as iron or copper. The castings should be tinned as soon as possible after plating.

Very large bearing shells cannot usually be accommodated in a tinning bath and they are generally preheated and then tinned by a manual wiping procedure in which flux is applied and a stick of tin is melted on to the surface and wire-brushed all over to give a uniform tin coating. Pre-tinning can also be carried out by using one of the methods previously described.

Standard Alloy Selection Guide

Type of Installation		Tin-Base Alloy (Grades 1-11)	Lead-Antimony-Tin Alloy (Grades 7-13)	Lead-Antimony-Arsenic Alloy (Grade 15)
Aircraft Engine		●		●
Blowers				
Blowing Engines: Reciprocating and Turbo			●	●
Centrifugal		●		●
Fans, Ventilating:	High Speed	●		●
	Low speed		●	●
Rotary: Sliding vane, gear or cam		●		●
Cement Mills				
Dryers, rotary; Kilns: Bearing rolls and reduction gear		●		●
Mixers; Rock Graders; Shafting: High speed and low speed; Winches			●	●
Screens:	Revolving		●	●
	Pulsating	●	●	●
Centrifugal Machinery (Extractors and Separators)				
Pedestal Bearings		●		●
All Other Bearings			●	●
Clay Working				
Auger Machines; Disintegrators; Granulator; Pug; Repress Machines;		●		●
Blunger; Cutting Machines; Lawns			●	●
Conical Mill; Ship Car and Hoist; Slip Pumps		●	●	●
Compression Ignition Engines (Diesel)				
High Speed (Over 700 R.P.M.):				
Main Crankshaft; Connecting Rods		●		●
Camshafts; All Other Bearings			●	

Type of Installation	Tin-Base Alloy (Grades 1-11)	Lead-Antimony-Tin Alloy (Grades 7-13)	Lead-Antimony-Arsenic Alloy (Grade 15)
Compression Ignition Engines (Diesel) cont.			
Marine Main Propulsion:			
Main crankshaft; connecting rods; crossheads	●		●
Camshafts; All Other Bearings		●	●
Compressors (Large, Heavy)			
Main Crankshaft; Connecting Rod Big Ends	●		●
Auxiliary Bearings; All Other Bearings		●	●
Crushing Machinery			
Ball Mill; Breaker Roll Type; Gyratory Type; Rod Mill Type; Roll Type; Tube Mill	●		●
Jaw Type: Backing-up jaws and bearings		●	●
Pan Type: Thrust Bearings	●		●
Pan Type: Other Bearings	●		
Roll Hammer Type	●		
Stamp Mill: Camshaft	●		●
Stamp Mill: Guides		●	●
Dredgers			
Bilge Pumps; Conveyors and Stackers; Hoist Sheaves; Revolving Screens; Shafting; Winches		●	●
Centrifugal Main Pumps; Compressors; Sluice Pumps	●		●
Tumblers: Upper	●	●	●
Tumblers: Lower		●	●
Electric Motors and Generators			
Traction Motors (Subways and Street Railways)			
Main Rotors	●		●
Armatures and axles; All Other Bearings		●	●

Type of Installation	Tin-Base Alloy (Grades 1-11)	Lead-Antimony-Tin Alloy (Grades 7-13)	Lead-Antimony-Arsenic Alloy (Grade 15)
Electric Motors and Generators (cont.)			
Stationary Motors and Generators (1,500 R.P.M. and above)			
Main Rotors	●		●
Armatures and axles; All Other Bearings		●	●
Stationary Motors and Generators (below 1,500 R.P.M.):			
All Bearings	●		●
Elevating, Conveying and Excavating			
Belt Conveyors: Carrier bearings and gravity take-ups; Take-up End; Cableways: Sheaves, drum shafts and reduction gears; Car Dumpers: Reduction gear and trunnions; Screw Conveyors; Trippers		●	●
Drive Ends	●	●	●
Bucket Elevator and Conveyor:			
Drive end	●	●	●
Take-up guides; pit bearings		●	●
Car Journals		●	
Cranes:			
Reductions; drum shafts	●		●
Trolley journals		●	●
Fans			
All Bearings	●	●	●
Gas Engines (Vertical and Horizontal)			
Main Crankshaft; Connecting Rod and Main Bearings; Camshaft; G.M.B. 2 Cycle, V Type Compressor Engines	●		●
All Other Bearings		●	●
Gasoline Engines			
Main Crankshaft; Connecting Rod Big Ends	●		●
Camshafts; Subsidiary Drive (to Oil Pump, Water Pump, Dynamos, etc.); Water Pump; All Other Bearings		●	●

Type of Installation		Tin-Base Alloy (Grades 1-11)	Lead-Antimony-Tin Alloy (Grades 7-13)	Lead-Antimony-Arsenic Alloy (Grade 15)
General Process and Production				
Machinery			●	●
Lumber Mills, Saw Mills and Planing Mills				
Conveyors: Live rolls, kickers, log carriage, shafting and winches			●	●
Conveyors: Car journals			●	
Conveyors: Hogs, saw grinders, mortiser, shaper, sizer, surfacer and tenoner		●		●
Saws		●		●
Machine Tools				
High Speed Grinding Machine; Stamps; Presses or Drop Hammers		●		●
All Other Bearings			●	●
High Precision Grinding Machine		●		
Mining				
Agitators; Car Wheel Journals; Feeders; Separation Machines; Shafting; Thickeners;			●	●
Classifiers			●	●
Concentrator Tables:	Head motion	●		●
	Rockers		●	●
Roasters:	Pinion bearings		●	●
	Thrust bearings	●		●
Screens		●	●	●
Oil Engines (not Compression Ignition)				
Main Crankshaft; Connecting Rod Big Ends		●		●
Camshafts; All Other Bearings			●	●
Paper Mills, Pulp Mills				
Agitators; Burners and Calciners; Cylinders and Val Machines; Deckle Pulleys and Dandys; Folders; Pressers; Reels; Save-Alls; Screens; Shaking Frame Gears; Slithers; Splitters; Stackers; Stock Chests; Winders; Thickeners			●	●

Type of Installation		Tin-Base Alloy (Grades 1-11)	Lead-Antimony-Tin Alloy (Grades 7-13)	Lead-Antimony-Arsenic Alloy (Grade 15)
Paper Mills, Pulp Mills (cont.)				
Barkers:	Drum type		●	●
	Disc Type	●		●
Beaters; Bleaching Engines; Chippers; Crushers and Rechippers; Cutters; Digestors; Drive Stands; Dusters; Grinders; Jordans; Lay Boys; Pulping Engines; Saws; Willows; Thrashers; Trimmers		●		●
Rolls:	Breast; table; couch		●	
	Press; calendar	●		●
Pumps				
Reciprocating:	Crankshaft, main and big end	●		●
	All Other Bearings		●	●
Centrifugal:	main shaft	●		●
	All Other Bearings		●	●
Railroad Bearings				
Engine, Cross Head, Truck Trailer, etc.		●	●	●
Car Journals			●*	
Rock and Gravel Plants				
Cars; Grizzlies; Screens; Scrubbers; Washers			●	●
Steam Engines (Reciprocating)				
Marine:				
Main propulsion; Main - crossheads and connecting rods		●		●
All Other Bearings			●	●
Ordinary Marine Auxiliary:				
Main - crossheads and connecting rods		●		●
All Other Bearings			●	●

*ASTM B67-38, AAR M-501-34

Type of Installation	Tin-Base Alloy (Grades 1-11)	Lead-Antimony-Tin Alloy (Grades 7-13)	Lead-Antimony-Arsenic Alloy (Grade 15)
Steam Engines (Reciprocating) (cont.)			
Stationary:			
Main - crossheads and connecting rods	●		●
Stationary:			
All Other Bearings		●	●
Steel Mill Bearings	●		●
Sugar Mills			
Agitators; conveyors; Crystallizers; Elevators; Lime Mixers; Malaxeurs; Minglers; Mixers; Rakes; Shafting		●	●
Cane Knives; Centrifugals; Crushers; Gear Drives; Grinding Rolls	●		●
Suspension Bearings (Vehicular)			
All Types	●		●
Transmission Bearings			
Reduction Gears:			
Turbine	●		●
All Other Bearings	●		●
Shafting Bearings:			
Marine stern tube bearings	●		
Marine line shaft bearings	●		●
Roller and Chain Conveyors	●		●
Turbines - Steam (Main Ship Propulsion and Industrial)			
Main Bearings	●		●
All Other Bearings			●

ASTM Specifications ASTM B-23

CHEMICAL COMPOSI-TION [1] (%)	TIN-BASE				LEAD-BASE			
	ALLOY NUMBER [2] (GRADE)							
	1	2	3	11	7	8	13	15
TIN	90.0 to 92.0	88.0 to 90.0	83.0 to 85.0	86.0 to 89.-0	9.3 to 10.7	4.5 to 5.5	5.5 to 6.5	0.8 to 1.2
ANTIMONY	4. 0 to 5.0	7.0 to 8.0	7.5 to 8.5	6.0 to 7.5	14.0 to 16.0	14.0 to 16.0	9.5 to 10.5	14.5 to 17.5
LEAD	0.35	0.35	0.35	0.50	remainder [3]	remainder [3]	remainder [3]	remainder [3]
COPPER	4.0 to 5.0	3.0 to 4.0	7.5 to 8.5	5. 0 to 6.5	0.50	0.50	0.50	0.6
IRON	0.08	0.08	0.08	0.08	0.10	0.10	0.10	0.10
ARSENIC	0.10	0.10	0.10	0.10	0.30 to 0.60	0.30 to 0.60	0.25	0.8 to 1.4
BISMUTH	0.08	0.08	0.08	0.08	0.10	0.10	0.10	0.10
ZINC	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
ALUMINUM	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
CADMIUM	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TOTAL NAMED ELEMENTS, Min.	99.80	99.80	99.80	99.80				

1. All values not given as ranges are maximum unless shown otherwise.
2. Alloy Number 9 was discontinued in 1946 and numbers 4, 5, 6, 10, 11, 12, 16 and 19 were discontinued in 1959. A new number 11, similar to SAE Grade 11 was added in 1966.
3. To be determined by difference.

SAE J460e Specifications

Chemical Composition[a] (%)

	SAE No.	Tin,min.	Antimony	Lead	Copper	Iron	Arsenic	Bis-muth	Zinc	Alumi-num	Others, Total
Tin-Base Bearing	11	86.0	6.0-7.5	0.50	5.0-6.5	0.08	0.10	0.08	0.005	0.005	0.20
Bearing	12[b]	88.0	7.0-8.0	0.50	3.0-4.0	0.08	0.10	0.08	0.005	0.005	0.20
		Lead	Tin	Antimony	Copper	Arsenic	Bis-muth	Zinc	Alumi-num	Cadmium	Others, Total
Lead-Base Bearing	13	Remainder	5.0-7.0	9.0-11.0	0.50	0.25	0.10	0.005	0.005	0.05	0.20
Bearing	14	Remainder	9.2-10.7	14.0-16.0	0.50	0.6	0.10	0.005	0.005	0.05	0.20
Bearing	15	Remainder	0.9-1.3	14.0-15.5	0.50	0.8-1.2	0.10	0.005	0.005	0.02	0.20
Bearing	16	Remainder	3.5-4.7	3.0-4.0	0.10	0.05	0.10	0.005	0.005	0.005	0.40

a. All values not given as ranges are maximum except as shown otherwise.
b. Formerly SAE 110.

QQ-T-390 Specifications

Chemical Composition (%)

Grade	Tin	Antimony	Lead	Copper	Iron, max.	Arsenic, max.	Zinc, max.	Alumi-num max.	Bis-muth max.	Other ele-ments max.
1	90.0-92.0	4.0-5.0	0.35[1]	4.0-5.0	0.08	0.10	0.005	0.005	0.08	0.10
2	88.0-90.0	7.0-8.0	0.35[1]	3.0-4.0	0.08	0.10	0.005	0.005	0.08	0.10
3	83.0-85.0	7.5-8.5	0.35[1]	7.5-8.5	0.08	0.10	0.005	0.005	0.08	0.10
4	80.5-82.5	12.0-14.0	0.25[1]	5.0-6.0	0.08	0.10	0.005	0.005	--	0.10
5	61.0-63.0	9.5-10.5	24.0-26.0	2.5-3.5	0.08	0.15	0.005	0.005	--	0.30
6	4.5-5.5	14.0-16.0	79.0-81.0	0.50[1]	0.10	0.20	0.005	0.005	--	0.50
7	9.3-10.7	14.0-16.0	74.0-76.0	0.50[1]	0.10	0.60	0.005	0.005	--	0.50
10	0.75-1.25	14.5-17.5[2]	78.0-83.0	0.60[1]	0.10	0.8-1.4	0.005	0.005	--	0.50
11	90-11.0	11.5-13.5	74.0-79.0	0.40-0.60	0.10	0.20	0.005	0.005	--	0.50
13	4.0-6.0	8.0-10.0	83.0-88.0	0.50[1]	0.10	0.20	0.005	0.005	--	0.75

[1] Maximum
[2] A narrower range of antimony within the limits stated may be specified but the spread shall be not less than 1.00 per cent.

Technical Report

Fry Grade 2 Babbitt Wire
For Spray Metallization

Description
Fry Grade 2 Babbitt wire provides effective and uniform spray metallization. It exceeds ASTM B23 Grade 2 specification and all federal and legal guidelines for lead-free alloys. Because the ASTM specification was developed for pouring operations, Fry developed this modified alloy with tighter impurity levels specifically for spray metallization. Fry is the first company to recognize the need for a specification for spray metallization.

Process
Fry Grade 2 Babbitt wire is a carefully homogenized alloy of relatively hard and soft microscopic particles. Strict temperature control during alloying insures a product of correct metallurgical structure. Casting and extruding is done in a unique process that produces a consistent alloy for drawing into wire. This process enables Fry to make the smallest diameter Babbitt wire available. Fry Grade 2 Babbitt wire is of uniform diameter and the lamination-free surface provides trouble-free machine feeding. Fry Grade 2 Babbitt wire is a superior trouble-free product.

Fry Grade 2 Babbitt Wire Benefits

1) No laminations that would cause deposition problems
2) Non-splitting, virtually weld-free wire with a non-flaking surface to prevent machine feeding problems
3) Available in diameters from .057 to .187"
4) Lead-free composition for environmental safety
5) Fry specification produces a soft, pliable wire for easier machine feeding
6) Homogenous structure and tight wire diameter provide even feeding and flame deposition.

Physical Data

Chemical Composition[1]	Fry Gr. 2 Babbitt Wire	ASTM B23
Tin	88.0-90.0	88.0-90.0
Antimony	7.0-8.0	7.0-8.0
Lead	.10[2]	.035
Copper	3.0-4.0	3.0-4.0
Iron	.02	.08
Arsenic	.02	0.10
Bismuth	.02	0.08
Zinc	0.005	0.005
Aluminum	0.005	0.005
Cadmium	.001	0.05
Silver	.02	not specified
Nickel	.02	not specified

(1) Limits are % maximum unless shown as a range.
(2) Exceeds all known state and federal legislative requirements.

Property		Fry Gr. 2 Babbitt Wire
Density		.267 lbs/in^3
Melting range		466-669 F
Brinell hardness	@ 77 F	24
	@ 212 F	12
	@ 320 F	6
Tensile Strength (psi)	@ 77 F	11200
	@ 212 F	6500
	@ 302 F	3000

Packaging

Fry Grade 2 Babbitt wire is available on 25 pound reels, 25 & 50 pound coils, and 100 or 300 pound pay-off-packs in diameters from .057 to .187.

POWER**BOND® **4200 TINNING COMPOUND

DESCRIPTION

***POWER**BOND® 4200* Tinning Compound is a dry mixture of pure powdered tin and flux specifically designed for pre-tinning cast iron, steel, bronze and copper bearing shells when a tinning bath, electrolysis or other tinning methods are not practical. A one pound container of ***POWER**BOND® 4200* contains about twice as much Tin and goes further than other tinning compounds currently on the market.

APPLICATION

Pre-clean and degrease bearing surface prior to tinning. Particular attention should be given to cast iron bearings to remove silica surface skins, graphite and other residues that may impair adhesion. Pre-heat bearing shell to approximately 500°-550°F (excessive heat may cause flux charring and premature tin oxidation). Sprinkle 4200 Tinning Compound on bearing surface and vigorously wipe with a stainless steel wire brush or steel wool to yield a smooth, well-tinned surface to which babbitt readily bonds. Flux residues are completely water-soluble and should be washed off promptly prior to babbitting.

PHYSICAL PROPERTIES

Appearance	Light, silvery gray powder
Water Solubility	Approximately 50%
Odor	None
Density	4.9 - 5.0 g/cm³ 300 - 310 lb/ft³
% Volatile	Zero
pH (10% aqueous solution)	1.5

AVAILABILITY

***POWER**BOND®* 4200 is available in 1 lb. plastic jars (18 per case) and 6 lb. plastic tubs (4 per case).

STORAGE

Keep container lid tightly closed when not in use. Store in a cool, dry place away from heat. Shelf life of this product is 1½ years if container is unopened.

SAFETY

While ***POWER**BOND* 4200 is not considered toxic, its use in typical heating processes will generate a small amount of decomposition and reaction vapors. These vapors should be adequately exhausted during heating. Consult MSDS for additional safety information.